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Engineering Division

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## INVESTIGATING STRUCTURAL FAILURES<sup>1</sup>

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Engineering Memorandum SCS-53 establishes a policy for the appointment of boards of inquiry to investigate failures of structures on projects within the administrative purview of the Service. The plan of operations to be followed by a board of inquiry should be based on the board's full consideration of the given problem. To insure that all essential elements of information are collected and reported in a usable form, general instructions for the conduct of inquiries are presented in this technical release. Plans of operations of boards of inquiry should conform to these instructions to the greatest practicable extent. CATALOGING - PREP.

Inspect the site. Note all visible symptoms of the failure, evidence of watermarks and all site conditions that may be pertinent to the evaluation of the failure. If borings, test pits, sampling or on-site tests are needed contact the State Conservationist immediately to arrange for such operations.

Study all pertinent records and documents. This study should include: (1) reports of previous inspections by other Service personnel; (2) statements of eye-witnesses; (3) construction records including diaries, reports, and test records; (4) the design file, with special regard for design investigation and survey reports, design assumptions, design criteria and design details; and, (5) construction specifications and contract modifications.

Interview key personnel and witnesses. Preferably at the structure site, interview such Service personnel and eye-witnesses as may be desirable to clarify or supplement pertinent information contained in reports and documents.

Summarize the facts. List the facts that are supported by evidence observed on the site, documented in investigation reports, noted in the design file, recorded in construction records, or stated by eye-witnesses. The list should include all pertinent facts, including:

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<sup>1</sup>This technical release was prepared by H. L. Cappleman, Jr., Assistant Chief, Design Branch.

- (1) A description of the failure, its symptoms and results, and, if possible, a statement of the sequence and timing of events prior to, and during, the failure;
- (2) A summary of the site conditions and the character of the materials as determined by the design investigations;
- (3) A description of the nature of the design with particular emphasis on the critical features that may be pertinent to the failure, and a list of the acknowledged (or clearly inferred) risks taken;
- (4) A summary of conditions encountered during construction, exposed by the failure, or disclosed by subsequent investigations, that differed from those assumed as a basis for design;
- (5) A summary of the background of experience in the use of similar designs under similar conditions;
- (6) A summary of the critical provisions of the construction specifications;
- (7) A summary of items in the construction records that may:  
(a) be pertinent to the time sequence of the failure, (b) indicate the scope and quality of the inspection, or (c) indicate whether or not the construction complied with the critical provisions of the specifications;
- (8) A summary of the actions taken subsequent to the failure.

Summarize the possible causes of failure. List all of the possible causes of failure that are consistent with the observed failure symptoms and known facts.

Evaluate data to determine probable cause. Evaluate each possible cause of failure in light of the known facts to determine which is the most probable. Such evaluation usually must be made by a deductive process involving: (1) a careful study of the facts, (2) a consideration of which facts are consistent with the mechanics of the assumed conditions, and (3) a consideration of which assumptions seem most plausible in light of the sequence and timing of events.

Evaluate the collection and interpretation of basic data. Study the design file to determine whether or not sufficient basic data were collected by means of surface reconnaissance, surveys, subsurface investigations, materials testing, hydrologic studies and other special studies to furnish an adequate basis for design. In the

course of this evaluation the board must judge whether or not: (1) the quantity of data collected is sufficient (consistent with the class of project) to represent all pertinent site conditions and hydrologic conditions; and, (2) the quality of the data collected is sufficient to allow reasonable confidence in the assumptions and approximations that were made in the establishment of design criteria.

If the quantity or quality of the basic data are not considered adequate, the board should determine whether or not: (1) the omissions, discrepancies or inadequacies were noted by the designer and reported by him to the authorities responsible for the collection of data; and, (2) if such reports were made, adequate and timely measures were taken to collect the necessary supplementary data.

Having evaluated the character of the basic data, the board should judge whether or not design assumptions, deductions and approximations represent a reasonable interpretation of the basic data in light of the facts known at the time the design was accomplished. Furthermore, if the record indicates that conditions encountered during construction were appreciably different from those assumed in design, the board should determine whether or not: (1) the changed conditions were adequately reported to the designer; and, (2) appropriate action was taken to verify the adequacy of the design or to modify it to compensate for the effects of the actual site conditions.

Evaluate the design. List and evaluate the features of the design that aggravate or alleviate the apparent failure conditions. This evaluation must consider the features that are normally required by professionally accepted design criteria to protect the structure from the effects of potentially dangerous conditions inherent in the site and materials. The effect of the incorporation or omission of specific design features must be carefully considered. Whenever the design file indicates that critical features were intentionally omitted or substantially modified as the result of the assumption of design risks, this fact must be analyzed in the light of prescribed criteria, Service experience, the conditions unique to the site, and professional acceptance of such risks. The board should thoroughly examine the justification for the assumption of design risk. By reviewing the pertinent files and interviewing cognizant personnel, the board should determine whether the assumption of risk was based on: (1) engineering interpretation of valid basic data; (2) arbitrary adjustment of criteria to limitations or commitments imposed in the planning phase; or, (3) arbitrary adjustment of criteria to limitations imposed by administrative decision in the operations phase. Copies of all data and correspondence bearing on the justification for the assumption of design risk should be collected for attachment to the report.



Evaluate the construction operation. List and evaluate the elements of the construction operation that might have a critical bearing on the type of failure considered most probable. The evaluation must consider the facts from three different standpoints: (1) whether or not the construction operation complied with the critical provisions of the contract specifications, (2) whether or not the contract specifications were adequate as applied to the project under consideration, and (3) whether or not the inspection program was adequate.

Prepare conclusions. From the evaluation of the facts prepare the conclusions that appear to be most reasonable with regard to:

- (1) Whether or not the proximate cause of failure can be determined (if so, it must be stated);
- (2) Whether or not responsibility can be assigned to: (a) planning deficiencies, (b) investigational deficiencies, (c) design deficiencies, (d) construction deficiencies, (e) any combination of procedural deficiencies, (f) natural occurrences beyond the reasonable control of the interested parties, or (g) administrative deficiencies;
- (3) If a combination of deficiencies is suspected but no tangible proof exists, whether or not the failure could have occurred even if the construction complied with the provisions of the specifications, and,
- (4) Whether or not Service criteria, procedures and actions were adequate.

Prepare recommendations. Recommend actions to be taken: (1) in repairing, replacing or abandoning the structure; (2) to improve planning, investigation, or design criteria or to insure the use of existing criteria; (3) to improve construction specifications or to insure the use of existing specifications; (4) to improve methods, procedures and policies for planning, design, inspection and construction management.

Write the report. The report should be carefully prepared to insure that all essential elements of the inquiry are summarized and explained. The report should conform to the format of the enclosed example. When supplementary documents and exhibits are required to be submitted with the report they should be listed as attachments.

U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE  
(Appropriate Location)  
(Date)

REPORT OF INVESTIGATION OF STRUCTURAL FAILURE

Project:  
Location:  
Site No. (or name of structure):  
Appropriation:  
Type of Failure:

Authority. (Refer to the letter appointing the board of inquiry.)

Composition of Board. (List names of board members.)

Scope. (Describe the scope of the inquiry and list site inspections; records, reports and documents reviewed; witnesses interviewed.)

Facts. (List all pertinent facts developed by the inquiry with reference to the supporting evidence.)

Discussion of Facts. (Include a complete discussion of possible causes of the failure, evaluation of data, deductions, assumptions, evaluation of the design, evaluation of the construction operations, and any other discussion that explains how the board arrived at its conclusions.)

Conclusions. (List conclusions supported by the discussion of facts.)

Recommendations. (List specific, concise recommendations for action.)

Attachments ( )

\_\_\_\_\_  
(Name), Chairman

\_\_\_\_\_  
(Name)

\_\_\_\_\_  
(Name)

